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THE POST-1973 PRODUCTIVITY SLOWDOWN
IN CANADIAN MANUFACTURING

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1. Introduction

Productivity growth rates dropped suddenly and sharply across the Western economies after 1973.[1]

Table 1 illustrates the productivity growth slowdown in real domestic product per employee in the Canadian manufacturing sector, which is the focus of the present study. Having grown at an average annual rate of 5% in the early 1970s (1971-73), labour productivity hardly increased in 1974, and fell slightly in 1975.

The purpose of this paper is to 'account for' changes in Canadian manufacturing productivity growth over the decade of the 1970s; with particular attention, of course, to the startling and worrying collapse in growth in the middle of the period.

It is worth observing at once that the Canadian experience does not match that of the United States. There, the concern has been with what appears to be a rather long-term deceleration of productivity growth. Clark, for example, reported that real output per worker hour in the U.S. private sector grew at nearly 3% per annum in the post-war period up to the mid-1960s, then at just 2% per annum between 1965 and 1973, before falling to 1% per annum over the 1973-78 period. He writes that

> '"the case of the missing productivity" is a two-part mystery extending through both the 1965-73 and 1973-78 periods' (1979, p. 431).[2]

In contrast, Table 1 shows that the average rate of labour-productivity growth in Canadian manufacturing was 3.7% p.a. up to 1964, and then increased to 4.0% p.a. over 1965 to 1973, before its collapse in 1974 and 1975.

Table 1 Canadian Manufacturing Output, Employment and Productivity Growth

	1	2	3	4
	RDP	EMP	PROD	% DPROD
1950	63.4	92.4	0.686	
1951	68.9	98.5	0.700	1.94
1952	71.5	100.1	0.714	2.07
1953	76.6	102.9	0.744	4.19
1954	74.9	97.8	0.766	2.97
1955	82.2	100.0	0.822	7.25
1956	89.9	105.5	0.852	3.70
1957	89.7	105.5	0.850	-0.22
1958	88.0	100.1	0.879	3.40
1959	94.5	102.0	0.926	5.39
1960	96.1	100.6	0.955	3.11
1961	100.0	100.0	1.000	4.68
1962	109.0	103.8	1.050	5.01
1963	116.2	106.1	1.095	4.29
1964	127.4	111.1	1.147	4.70
1965	138.8	117.2	1.184	3.28
1966	148.7	123.5	1.204	1.67
1967	152.3	123.2	1.236	2.67
1968	162.5	122.1	1.331	7.66
1969	173.5	125.2	1.386	4.13
1970	173.0	122.8	1.409	1.66
1971	180.0	121.6	1.480	5.07
1972	192.8	123.7	1.558	5.28
1973	211.7	129.9	1.630	4.56
1974	219.6	133.8	1.641	0.72
1975	205.7	126.3	1.629	-0.75
1976	217.1	128.1	1.695	4.03
1977	220.0	126.3	1.742	2.77
1978	232.6	127.6	1.823	4.65
1979	241.6	131.4	1.838	0.87
1980	234.5	129.0	1.818	-1.11
1981	237.0	129.8	1.826	0.42
1982	209.9	117.7	1.783	-2.32
1983	222.5	114.0	1.952	9.46

Definitions and Sources:

Real Domestic Product in Manufacturing: Up to 1971, based on the 1960 SIC, from Canadian Statistical Review: Historical Summary 1970, Catalogue 11-505, Table 2. From 1971, based on the 1970 SIC, from Canadian Statistical Review, selected economic indicator, catalogue 11-003, various issues.

Index of Employment: Up to 1957 based on 1948 SIC, from 1957 based on 1960 SIC. Sources as for RDP.

Productivity defined as RDP/Employment.

RDP = real domestic product; EMP = employment; PROD = productivity; % DPROD = annual percentage change in productivity.

Table 1 also reveals that there was a quite strong recovery in productivity growth in the late-1970s before the dreadful years of 1980-82. Finally, the (unrevised) data for 1983 indicate a remarkable pick-up in productivity growth in that year. It seems that employees only responded to the sharp recession-induced cuts in output (column 1) with a lag, so that it wasn't until 1983 that adjustments to labour forces were completed (column 2).[3]

However, the data for the 1980s are too raw to support conclusive analysis. This study makes use of a new Statistics Canada 'micro' database covering the 1970 to 1979 period. The database includes all manufacturing establishments (plants) reporting on 'long forms' to Statistics Canada's annual Census of Manufactures. Only very small plants, accounting for around 3 percent of total manufacturing shipments, are excluded.

The data are available annually, but to keep the operation within reasonable cost and time constraints, the 1970-79 period was divided into three equal sub-periods. We will look at productivity growth over the last of the high-growth years, 1970 to 1973; over the 1973-76 period, which includes the two years of low or negative growth, and over the 1976-79 period of partial recovery.

Because there was recovery (in contrast, it seems, to the United States experience), our concern is not so much with the post-1973 slowdown for its own sake, but for the insights that detailed analysis of swings in productivity can give to the underlying process of productivity growth. Cyclical fluctuations in productivity give us the statistical variability that we need to pin-down the causes of productivity changes. In particular, we will attempt to replicate with the disaggregated data the

findings of Helliwell (1984) that the Canadian slowdown can be largely explained by the two great macro-economic events of the early 1970s -- the 1973-4 OPEC oil price increases, and the sharp recession that followed on this as most OECD economies attempted to compensate for the supply-side inflationary impact of higher energy prices by restricting aggregate demand.

The analysis is in two stages: first measurement, then explanation. In the first stage (chapter 2), the disaggregated data are used to explore just where the slowdown (and recovery) occurred. In particular, we can split-out the effects on productivity of 'structural' shifts in the distribution of output between industries, and between plants (including entering and exiting plants) within industries, from changes within plants.

As well as being of considerable interest in themselves, the results of this exercise serve to focus the next stage of the investigation, the explanation of why the slowdown and recovery occurred. It turns out that structural factors were not very important, which narrows down the search to analysis of behaviour within plants. This is helpful because it allows us to make use of the standard procedure of using econometric techniques to estimate production or cost functions. This methodology applies micro-economic models of the optimizing behaviour of individual firms to aggregated databases. Typically, no heed is paid to possible problems with the aggregation process. These would certainly arise if a significant amount of the variation in the aggregate data were due, for example, to changes in exit and entry rates. Lack of such structural events is not, of course, sufficient for aggregation to be uncomplicated,

but it is at least <u>necessary</u>, and perhaps helps justify the standard practice, followed here, of implicitly assuming-away aggregation biases.

A quite simple econometric model of productivity growth changes is presented in chapter 3. It attempts to sort out the effects on productivity of demand fluctuations and energy price increases at the 3-4 digit SIC level, taking advantage of the substantial inter-industry differences at this level with respect to both cyclical demand fluctuations and exposure to energy price shocks.

Chapter 3 also includes analysis of a long list of other factors that have been suggested as possible contributors to the productivity slowdown. Most of these (for example, reduced labour-quality, lower investment rates, increased regulatory interference) are more plausibly aimed at the U.S. experience of an apparent long-term decline in productivity growth, rather than at the more cyclical Canadian events, but the available evidence for their applicability here is examined as closely as possible. Overall, the chapter appears to support the primacy of energy and demand shocks as claimants to account for the Canadian slowdown.

The final chapter draws some conclusions from the results of the study; in particular, looking at their applicability to the design of 'industrial policies' aimed at increasing the rate of manufacturing productivty growth. The findings do not support those who believe micro-economic productivity-enhancing policies to be feasible or desirable.

2. Measuring the Slowdown and Recovery

This chapter makes use of the micro-database to measure, at a level of detail which has not before been possible, the dimensions of the productivity growth slowdown and partial recovery that took place within the Canadian manufacturing sector over the 1970s. Whereas most previous Canadian work has been at the "one digit" (aggregate manufacturing) or "two-digit" (about twenty industries) level,[4] we have been able to examine productivity at a mixed three and four-digit level of disaggregation (about 150 industries), and, below that, for various groupings of plants within each three/four-digit industry.

Working at this level has major advantages. At the three four-digit level there are a number of industries whose productivity growth increased after 1973, against the general trend. This sort of variance in the data will be a fruitful basis for the econometric investigations of chapter 3. And being able to look inside industries, at selected groupings of plants, allows us to evaluate the relative contribution to industry-level productivity growth of changes in the distribution of output between plants, compared with changes in the performance of individual plants.

The only disadvantage of the new data is the cost of using it. Being so large, the database is expensive to prepare and manipulate. This means that the research strategy had to be fairly tightly specified in advance, with limited room for major alterations in the light of experience gained as the study proceeded.

The data were available for the years from 1970 through to 1979. This permitted us to analyze and compare productivity growth over three equal-length sub-periods - 1970 to 1973, 1973 to 1976, and 1976 to 1979.

The first of these includes the last years of the high-growth period that began in the 1960's. The second period encompasses the sharp slowdown (in fact cessation) of productivity growth that occurred in the manufacturing sector after 1973. And the third period revealed the extent to which the slowdown was permanent - that is, the extent to which growth has returned to its earlier levels.

Previous work has largely focussed on labour productivity - gross or net output per employee. While this is an appropriate concept at the aggregate level - it measures how productively an economy utilizes its major primary resource - people- it becomes problematic at the disaggregated industry level, where much of the labour input is embodied in the intermediate goods and services purchased from other industries. At this level, measured labour "productivity" can change if firms alter the proportion of work that they buy-in from other firms rather than undertake themselves, even if there is no change in output or input in the system at large. This problem is avoided if value added, or "net" output, which excludes intermediate inputs, is used as the numerator of the productivity measure, but then other conceptual and measurement problems arise (Denny and Fuss, 1982, p. 10).

The present study makes use of new Statistics Canada price index data for intermediate inputs, and an expanded set of (gross) output price indices to measure what is called "variable factor productivity" - output per unit of expenditure of materials, fuels, and labour, when all are deflated by the appropriate price indices. (In fact, because it leads to more convenient decompositions of the data at the within- or "intra-"

industry level, we used the inverse of productivity - constant-price costs per unit output as our variable).

Variable factor productivity excludes the services of capital, and any other inputs, such as entrepreneurial ability, which are not measured in the Census of Manufactures database. It is unfortunate that questions on capital stock, at least, are not included in the Census questionnaire, as they are in the United States (which does not, however, have a comprehensive annual Census as we do in Canada). There are some capital stock figures available from other Statistics Canada sources, but these are only at the industry level,[5] and were only available for 1970 and 1979 on the Baldwin-Gorecki database from which they could be drawn.

Omission of capital inputs would be a definite problem if we were dealing with the U.S. experience of an apparent long-term decline in productivity growth (notwithstanding which, many U.S. studies do only look at labour productivity). But we saw in chapter one that the fall in productivity growth after 1973 in Canadian manufacturing was part of a short-term or cyclical pattern rather than a continuation of a falling trend.

This being the case, and given that capital is a highly durable input, it seems *a priori* most unlikely that fluctuations in capital stock could have been the source of cyclical fluctuations in variable-factor productivity. That is, it is unlikely that the fall in labour-productivity in 1974 and 1975 was due to a reduction in the capital/labour ratio. If this is correct, we are justified in examining labour or variable-factor productivity, even if our ultimate interest is in total-factor productivity growth. The two will be closely correlated over the business cycle time horizon that we are dealing with.

There is some direct evidence on the role of capital in Canadian productivity growth over the period at a more aggregated level; this supports the position taken here, and will be discussed in chapter three.

In the remainder of the chapter we first set out the accounting framework within which the data will be examined, then describe the data themselves in more detail, and finally, show the results.

2.1 Accounting Framework

For some industry, unit costs:

$$UC = \frac{C}{Y} \tag{1}$$

where C is the sum of labour, materials and supplies and fuel and electricity costs, and Y is the value of gross output ("value of production").

The change in unit costs between two years 0 and 1 is:

$$DUC = UC_1 - UC_0 \tag{2}$$

with output and the components of costs all deflated by suitable price indices. Thus a negative value for DUC indicates a fall in costs (an increase in productivity).

We now decompose industry costs in each year. In year 0, the industry is made up of two types of plants: those that will still be in the industry in year 1, and those that will not. We call the first category "survivors" (S) and the second "exits" (X). Then

$$(3) \qquad UC_0 = \frac{C_{SO} + C_{XO}}{Y_{XO} + Y_{XO}}$$

$$(4) \qquad = \frac{C_{SO}}{Y_{SO}} \cdot \left(\frac{Y_{SO}}{Y_{SO} + Y_{XO}}\right) + \frac{C_{XO}}{Y_{XO}} \cdot \left(\frac{Y_{XO}}{Y_{SO} + Y_{X0}}\right)$$

$$= UC_{SO} \cdot W_{SO} + UC_{XO} \cdot W_{XO}$$

where UC_{SO} and UC_{XO} are the unit costs in year 0 of survivors and exists, and W_{SO} and W_{XO} are their respective shares in industry output.

Similarly, in year 1, the industry is made up of the surviving plants, and plants not in the industry in year 0. We call the latter category "entrants" (N). Then, as with year 0 costs:

$$(6) \qquad UC_1 = \frac{C_{S1} + C_{N1}}{Y_{S1} + Y_{N1}}$$

$$(7) \qquad = UC_{S1} \cdot W_{S1} + UC_{N1} \cdot W_{N1}$$

Now return to the change in costs:

$$DUC = UC_1 - UC_0$$

$$= UC_{S1} \cdot W_{S1} + UC_{N1} \cdot W_{N1}$$

$$(8) \qquad - UC_{SO} \cdot W_{SO} - UC_{XO} \cdot W_{X0}$$

Note that

$$(9) \qquad W_{S1} = 1 - W_{N1}$$

$$(10) \qquad W_{SO} = 1 - W_{XO}$$

so that

$$\text{(11)} \quad DUC = UC_{S1} + (UC_{N1} - UC_{S1})W_{N1} - UC_{SO} + (UC_{SO} - UC_{XO})W_{XO}$$

$$\text{(12)} \quad = DUC_S + DUC_{NS} \cdot W_{N1} + DUC_{SX} \cdot W_{XO}$$

where DUC_S is the change in unit costs of plants surviving from year 0 to year 1; DUC_{NS} is the difference (in year 1, of course) between the unit costs of entrants and survivors; and DUC_{SX} is the difference (in year 0) between the unit costs of survivors and exits.

Thus far, the change between two years in the industry's costs per unit output has been decomposed into five components:

1. the change in costs of plants surviving through the period (DUC_S);
2. the difference in year 1 in unit costs between plants entering the industry after year 0 and surviving plants (DUC_{NS});
3. the share of industry output taken by entrants in year 1 (W_{N1});
4. the difference in year 0 in unit costs between surviving plants and plants exiting from the industry before year 1 (DUC_{SX}); and
5. the share of industry output taken by plants that will not survive through the period, in year 0 (W_{XO}).

We can go further. It will turn out that, over the period-lengths to be considered in this study, surviving plants take a very large share of industry output, on average. Thus it is interesting to decompose further this sector of industry. A natural way of doing this is to divide survivors into "high-" and "low-cost" segments, according to the level of their unit costs in year 0. Then productivity growth performance - the change in unit costs - can be compared for two segments of differing levels of productivity.

Accordingly, in each industry, unit costs in year 0 were calculated for each plant surviving to year 1. The plants were then ranked from lowest- to highest-unit costs, and the entire sample divided into two segments, as nearly equal in size (gross output) as the discreteness of the data permit.

Thus we have, analogous to (5):

(13) $$UC_{SO} = UC_{LSO} \cdot W_{LSO} + UC_{HSO} \cdot W_{HSO}$$

(14) $$UC_{S1} = UC_{LS1} \cdot W_{LS1} + UC_{HS1} \cdot W_{HS1}$$

using "L" and "H" to denote the low-cost and high-cost segments of the industry, and with

(15) $$W_{LSO} + W_{HSO} = 1$$

(16) $$W_{LS1} + W_{HS1} = 1$$

Except in a very "lumpy" industry, W_{LS0} will be close to 0.5, but this need not be so of W_{LS1}.

Then

$$
\begin{aligned}
DUC_S &= UC_{S1} - UC_{S0} \\
&= UC_{LS1}(1-W_{HS1}) + UC_{HS1} \cdot W_{HS1} \\
&\quad - UC_{LS0}(1-W_{HS0}) - UC_{HS0} \cdot W_{HS0} \\
&= DUC_{LS} \\
&\quad + DUC_{HLS1} \cdot W_{HS1} \\
&\quad - DUC_{HLS0} \cdot W_{HS0} \qquad (17)
\end{aligned}
$$

where

(18) $$DUC_{LS} = UC_{LS1} - UC_{LS0}$$

(19) $$DUC_{HLS1} = UC_{HS1} - UC_{LS1}$$

(20) $$DUC_{HLS0} = UC_{HS0} - UC_{LS0}$$

Equation (17) can be expressed as:

(21) $$
\begin{aligned}
DUC_S = DUC_{LS} &+ (DUC_{HLS1} - DUC_{HLS0}) \cdot W_{HS1} \\
&+ (W_{HS1} - W_{HS0})DUC_{HLS0}
\end{aligned}
$$

That is, the change in costs of plants surviving through the period has been decomposed into five components:

1. the change in costs of surviving plants that were "low-cost" in year 0 (DUC_{LS});

2. the change from year 0 to year 1 in the cost differential between low-cost and high-cost plants ($DUC_{HLS1} - DUC_{HLSO}$);

3. the share in surviving-plant output in year 1 of plants that were in the high-cost segment in year 0 (W_{HS1});

4. the change between year 0 and year 1 in the output share of year 0 high-cost plants ($W_{HS1} - W_{HSO}$); and

5. the year 0 cost differential between high- and low-cost surviving plants (DUC_{HLSO}).

Equations (12) and (21) give us a decomposition of an industry's productivity growth into nine independent pieces of information. Naturally, further decompositions could be undertaken (such as distinguishing entering plants owned by entering firms from those built by firms in the industry throughout the period), but for reasons of time, cost, and analytical tractability, I have made do with the decomposition set-out above. Given that all nine pieces of information are novel, in that data on them have never before been available, they should yield plenty of interesting insights.

However, industry-level data do not complete the picture. Our ultimate interest is in the manufacturing sector as a whole, and we must therefore aggregate the industry-by-industry figures to the sectoral level.

We introduce the subscript "i" for industry i. Note that manufacturing unit costs

(22) $$UCM = \frac{\Sigma^n C_i}{\Sigma^n Y_i}$$

if there are n industries in the manufacturing sector. Analogously to equation (5), write

(23) $$UCM = \Sigma^n UC_i \cdot W_i$$

where

(24) $$W_i = \frac{Y_i}{\Sigma^n Y_i}$$

- the share of industry i in total manufacturing output. Then (reintroducing the year subscripts 0,1):

$$DUCM = UCM_1 - UCM_0$$

(26) $$= \Sigma^n UC_{i1} \cdot W_{i1} - \Sigma^n UC_{i0} \cdot W_{i0}$$

$$= \Sigma^n [UC_{i1} \cdot W_{i0} + (UC_{i1} \cdot W_{i1} - UC_{i1} \cdot W_{i0}) - UC_{i0} \cdot W_{i0}]$$

(27) $$= \Sigma^n [DUC_i \cdot W_{i0} + UC_{i1} (W_{i1} - W_{i0})]$$

Equation (27) reveals manufacturing cost change to be the sum of two terms:

- the output-weighted sum of individual industry cost changes; and

- the changes in output shares weighted by the unit costs of each industry.

That is, sector-level productivity growth depends not just on the performance of individual industries, but also on the relative size of unusually fast- (or slow-) productivity growth industries; and on whether there is any systematic tendency for changes in the share of manufacturing output to be concentrated in industries with unusually high (or low) levels of productivity.

Expressions (12), (21) and (27) give us a useful framework within which to examine the data on cost changes.

2.2 Data

Statistics Canada collects information for every plant and firm in the manufacturing sector in their annual Census of Manufactures. This information is now stored so that it is computer-accessible.

Thus, it is possible to analyse data below the mixed 3- and 4-digit Standard Industrial Classification (SIC) level of aggregation at which Statistics Canada publish annual reports on the manufacturing sector.

A further attractive feature of the database is that each firm and plant in it is assigned a unique identifying code number, so that its progress can be tracked from Census to Census. Thus units can be followed from their entry into an industry until their eventual exit (should such occur). It is this feature that permits the disaggregation of plants into "entrants", "exits" and "survivors" that was developed in the previous section.

A disadvantage of the database is that it must be analysed "in house" at Statistics Canada, to avoid contravening the confidentiality requirements of the Act of Parliament under which Statistics Canada operates. This means (a) analysis is costly; and (b) most of the calculated values of the variables listed in the previous section cannot be published.

However, the researcher, once vetted by the RCMP, can earn a security clearance to examine the unpublishable data, in order to check them for errors. Such checks have been carried out in the course of the present study (and errors were found!).

The computer-accessible data extend back to 1970 (the year in which an SIC revision was introduced), and as far forward as 1979. This permits calculation of growth rates from 1971 to 1979. As noted, the data were divided into three equal-sized periods - 1970-73, 1973-76, and 1976-79.

The mixed 3- or 4-digit SIC by which the data are classified has 167 industries. For each of these data are available on value of output, cost of materials and supplies, cost of fuels and electricity, and numbers of employees and their wages and salaries.

In fact, the Census data do not cover 100 percent of the plants involved in manufacturing. Very small plants are asked to fill in "short forms" which yield less information than the "long forms" used to compile our database. Exact criteria for short form status differ between SICs, but the overall result is that only two or three percent of manufacturing output is excluded from our sample.

Statistics Canada publish a series of "industry selling prices" (ISPs), which are deflators for manufacturing gross output. Recently they have made available unpublished data (compiled for use in their Input- Output tables) which (a) extend the coverage, by SIC, of the ISPs, and (b) introduce price indices, by SIC, for materials and fuels purchases.[6]

It is the availability of these new price data that permits us to calculate the variable-factor productivity measures used in this study. Series for the "price" of labour are not published, but an acceptable substitute can be calculated from Census information by dividing the value of wage and salary payments by the number of employees.

The price indices for output and materials are built up from samples of observations on prices, and are only released if Statistics Canada are confident that the margin for sample error is acceptably small. This means that price data for individual plants, or sets of plants, are not available.

In consequence, we have had to use the same price deflators for the output (and for the material, etc., inputs) of surviving and entering plants in each SIC industry.

In addition, two SICs (2611, 3988) do not have any price indices calculated, and some others are assembled in groups of two or more, and assigned the same price index (because of properties of the price samples). Exclusion of these SICs reduces the sample for the present study to 144 industries (from the 167 SICs into which Canadian manufacturing is divided).

Because at the commodity level many price indices (for output, though not for materials) are available below the 3 or 4 digit SIC level of disaggregation, and because the Census of Manufactures database does include information on the mix of these commodities produced by each plant, it would be possible, at some expense, to construct indices for subsets of plants below the 3/4 digit SIC level which would at least allow for differences in the output mix (though still not allowing for any difference in prices at which the "same" commodity is sold by each subset). Such an undertaking should be included on the list of possible extensions to the database.

2.3 Results

The variables decomposing changes in unit costs according to equations (12), (21) and (27) are set out in Table 2 (with an accompanying key linking the rows of the table to the algebraic expressions).

Values were calculated for the sample of 144 Canadian manufacturing industries for each of the periods 1970 to 1973, 1973 to 1976, and 1976 to 1979. Variables in the first twelve rows of the table are computed for each of the 144 industries: numbers shown on the table are unweighted means across the sample.

The analysis of this section will be in three steps. First we will examine the process of growth over the 1970-73 period. Then we will look at changes in the process between this period and the 1973-76 years. That is, we will examine the "slowdown". Finally, the third (1976-79) period will be examined and compared with the others.

2.3.1 Growth Between 1970 and 1973

The bottom line of the table is also the "bottom line" of economic performance: the change in total manufacturing real unit costs per unit of real output. Line 15 shows that unit costs in the sector were 2.28 per cent lower in 1973 than their 1970 level.

That is, productivity in the manufacturing sector, by this measure, increased at an annual rate of rather less than 1 per cent over the 1970-73 period.

This is a smaller number than we are used to seeing for productivity growth in the pre-slowdown period. For example, Denny and Fuss report (1982, p. 22) the Finance Department's figure of 4.5 per cent for annual productivity growth in manufacturing from 1967 to 1973.

The differences are due to differences in both numerator and denominator of the productivity measure. The 4.5 per cent number measures change in value added per employee, whereas our number is (the inverse of) gross output per variable factor input.

Berndt and Watkins have shown that a gross output productivity growth measure will be less than a net (value added) measure by a proportion equal approximately to the ratio of gross output to value added, which is larger than two, on average, in the Canadian manufacturing sector (1981, p. 6). As well, if most productivity improvement is in the use of labour rather than materials, our labour-plus-materials productivity growth numbers will be further reduced compared to the labour productivity measures. The aggregate data published by Statistics Canada show that materials productivity varies very little. Compared with 1971, the ratio of (constant price) intermediate inputs (materials

Table 2: <u>Changes in real unit variable costs in Canadian Manufacturing Industry</u>

	1	2	3	4	5
	1970-73	difference 73-76/70-73	1973-76	difference 76-79/73-76	1976-79
1. Average share exiting plants in industry output, start-period	0.033		0.020		0.026
2. av. contribution of exiting plants to % change manufacturing costs	-0.045	-0.032	-0.077	0.044	-0.033
3. av. % change costs of "low-cost" surviving plants	2.51	3.38	5.89	-2.33	3.56
4. av. % difference "high-cost"/"low-cost" plants' costs, stat-period	23.77		23.97		24.49
5. av. % change in difference in "high-cost/"low cost" plants' costs	-11.05		-10.84		-12.60
6. av. change in output shares of high-cost plants	0.009		0.008		0.012
7. av. contribution of "high-cost" plant catch-up to manufacturing costs	-5.75	0.37	-5.38	-1.19	-6.57
8. av. contribution change in output shares of high-cost plants (=4x6)	0.32	-0.05	0.27	0.07	0.34
9. av. contribution change in costs of surviving plants (=3+7+8)	-2.92	3.70	0.78	-3.45	-2.67
10. av. share entering plants in industry output, end-period	0.034		0.014		0.025
11. av. contribution of entering plants to % change manufacturing costs	0.02	-0.01	0.01	0.03	0.04
12. av. % change in industry costs (=9+2+11)	-2.93	3.64	0.71	-3.38	-2.67
13. contribution to total manufacturing of industry-level cost changes	-2.46	3.03	0.57	-2.45	-1.88
14. contribution to total manufacturing of shifts in industry output share	0.18	0.09	0.27	-0.43	-0.16
15. total manufacturing % change in unit costs (=13+14)	-2.28	3.12	0.84	-2.88	-2.04
Sample size = 144					

Key to Table 2

Found in Equation	Row	
12	1	W_{XO}
12	2	$DUC_{SX} \cdot W_{X0}/UC_0 \cdot 100$
21	3	$DUC_{LS}/UC_0 \cdot 100$
21	4	$DUC_{HLS0}/UC_0 \cdot 100$
21	5	$(DUC_{HLS1} - DUC_{HLS0})/UC_0 \cdot 100$
21	6	$W_{HS1} - W_{HS0}$
21	7	$(DUC_{HLS0} - DUC_{HLS0}) \cdot W_{HS1}/UC_0 \cdot 100$
21	8	$(W_{HS1} - W_{HS0})DUC_{HLS0}/UC_0 \cdot 100$
12,21	9	$DUC_S/UC_0 \cdot 100$
12	10	W_{N1}
12	11	$DUC_{NS} \cdot W_{N1}/UC_0 \cdot 100$
12,27	12	$DUC/UC_0 \cdot 100$
27	13	$\Sigma DUC \cdot W_0/UCM_0 \cdot 100$
27	14	$\Sigma UC_1(W_1 - W_0)/UCM_0 \cdot 100$
27	15	$DUCM/UCM_0 \cdot 100$

and fuels) to gross output in 1979 was 2 percent higher in Durable Manufacturing and less than 1 percent higher in Non-durables, and these figures did not show much year-to-year fluctuation. Since materials costs average about 3/4 of total (materials plus labour) variable costs, labour productivity growth would be about x4 larger than the unit variable cost figures shown here. These differences are not particularly important, so long as we are consistent in comparing like with like, and in the present paper only the unit variable cost measure of productivity is analysed.

Returning then, to the 1970-73 data in the first column of Table 2, we decompose the total manufacturing fall in unit costs according to equations (12), (21) and (27).

Note first that the unweighted average of the 144 industries' change in costs (row 12) is nearly 3 percent - larger than the total manufacturing number. Comparing rows 12 and 13, we see that about one half of a percentage point of the difference between rows 12 and 15 is due to a tendency for relatively high-productivity growth industries to be smaller than average. This is not surprising, given that relatively new industries can be expected to be both smaller and faster-growing than the norm.

The remainder of the differences between weighted and unweighted productivity growth is row 14 - the contribution of shifts in the share of total manufacturing output taken by individual industries. This number is small but positive, revealing a slight tendency for resources to move towards high-unit cost activities.

So much for the inter-industry decomposition of growth. We now turn to the intra- or within-industry events, which were broken down in equations (12) and (21). We will examine in turn the contribution made by exiting, surviving and entering plants over the 1970-73 period.

Row 1 shows that the set of plants operating in 1970 but not in 1973 had just over 3 percent of industry output, on average. The average conceals some wide variations across the sample - there were several SIC industries in which no plants were closed over the period, and, at the other extreme, one in which more than one third of 1970 output came from plants that did not survive to 1973.

Row 2 gives the average net effect of exits on productivity growth. The number is negative, implying that exiting plants have higher unit costs than survivors. This is as we would expect, but note how small is the contribution to industry productivity growth of these plants - about one sixtieth of the 2.9 percent average change in costs. The contribution is limited by the relatively small proportion of plants that exited over the three years, but it can be calculated from equation (2) that unit costs of exits and survivals differed, on average, by only one percent.

For the full 1970-79 period, the Baldwin-Gorecki database shows that exiting plants account for about 30 percent of 1970 output (Baldwin and Gorecki, 1983, p. 9). The discrepancy between this number and the three sub-period numbers in row 1 of Table 2, which sum to about 0.08 - 8 percent - tells us that exit is typically preceded

by a period of decline.

For example, consider a plant which closes down (exits) in 1975. In a 1970-79 database the size of this plant would be measured in 1970, whereas in the sub-period analysis it would be its size in 1973 (the start of the second period) that would be placed on the database. Thus the larger output share figure when all the exiting plants are measured in 1970 rather than in 1973 or 1976 (for plants dying after 1973) implies that these plants are larger relative to survivors the longer in time before their disappearance that they are measured.

However, this observation does not imply that the short-period analysis necessarily underestimates the contribution to productivity growth of the processes inducing plants to exit. Presumably the cost differential between survivors and exits is less the further from the latters' demise that costs are measured.

Rows 3 to 9 break down the cost changes of plants surviving through the period according to equation (21). The "bottom line" of this sample of plants is their contribution (row 9) to average total productivity growth (row 12), and we see that the numbers are almost the same for the 1970-73 period.

That is, it is plants already in existence in 1970, and still in existence in 1973, that are responsible for nearly all industry-level productivity growth.

The rows above row 9 show how the productivity performance of survivors differed in the "high-" and "low-cost" segments of industries.

Row 3 reveals that low-cost plants, on average, increased their unit costs by about 2.5 percent from 1970 to 1973. The reason for this is revealed by the next two lines. Though the average 1970 cost difference of high-cost and low-cost segments came to nearly 24 percent of average total-industry unit costs (row 4), nearly one half of the differential was eliminated by 1973 (row 5).

That is, there is, typically, a considerable amount of mobility between high-cost and low-cost segments. It is not possible to infer from these figures whether this mobility is due to random errors in the data or to genuine serendipity in the fortunes of firms.

The extent of change in reported cost performance over only three years does suggest caution in proceeding with any sort of "industrial policy" that requires policymakers to "pick winners" (or, for that matter, to pick losers). A large proportion of the "winning" plants in 1970 were no longer relatively good performers in 1973.

The average net effect of 1970 high-cost plants catching up with low-cost plants is a decrease in unit costs of nearly 6 percent (row 7), which more than compensates for row 3's evidence of increases in costs of 1970 low-cost operators.

1970 high-cost plants tend slightly to increase their share of industry output (row 6). While this would be disturbing if the high-cost/low-cost distinction was near-permanent, or "structural", it in fact probably reflects, given the extent of mobility within the cost distribution, the effect of cost-improving plants succeeding also in raising their output share.

Nevertheless, the arithmetic implication of the formula of equation (21) is that the change in output shares contributes to cost changes on the positive side of the ledger (row 8).

The net effect, as noted, is that surviving plants on average reduced their industry's unit costs by nearly 3 percent between 1970 and 1973 (row 9).

These figures suggest that the high/low-cost distinction is not particularly useful to a decomposition of the productivity growth process. Mobility betwen high- and low-cost segments means that we have failed to identify two stable groups of relatively good and bad performers with respect to the start-period level of productivity, whose subsequent performances vis-a-vis productivity <u>growth</u> could be compared with interest. With hindsight, it would seem to have been preferable to divide-up surviving plants into four segments - (a) those in the 1970 low-cost half who are still low- cost in 1973; (b) those which are high-cost in both years; and (c), (d) those plants which move between segments. It may be possible to implement this disaggregation in future work.

Rows 10 and 11 on Table 2 pick up the third ingredient in the intra-industry decomposition of productivity growth - the contribution of new plants. Plants entering after 1970 produced 3.4 percent of 1973 output, on average. This figure is similar to the share of 1970 output produced by exiting plants (row 1), and is consistent with the age distribution of plants remaining about constant over the period.

This number that does surprise is in row 11. Entrants

<u>increase</u> industry costs, on average, by a small amount. Now, we expect that new plants will be built with best-practice technology and be therefore more productive - have lower unit variable costs - than the average of existing plants, so that their addition to an industry should lower the industry cost average. That this does not occur is a matter of interest, or even concern. Substituting mean values into equation (12) allows us to calculate that new plants' unit costs were about 1/2 percent higher than survivers'.

A clue to this puzzle is provided by data on the size of plants. In 1973, plants surviving from the 1970 Census had, on average, output of $3.5 million. Plants entering since 1970 had output levels averaging less than $2 million. Unless there was a considerable reduction across the manufacturing sector in efficient plant scale, these numbers suggest that there are adjustment costs which prevent new plants from immediately achieving scale-efficient operating levels.

In terms of the standard microeconomic model of the firm, new plants tend to be operating on the left-hand side of their average cost curves, above the point of minimum costs. This is why, in the short-to-medium term time horizon (one to three years), new plants do not contribute to productivity growth.

To summarize: nearly all of the productivity growth in the manufacturing sector from 1970 to 1973 was due to cost decreases in plants in existence throughout the period, reinforced a little by some closing-down of plants which had higher-than-average cost in 1970. Against these productivity-increasing forces ran (a) a tendency for

highest productivity growth rates to occur in relatively small industries, (b) a tendency for output shares of relatively high-cost industries to increase, and (c) a slight tendency for new plants to operate at higher costs than the average.

2.3.2 The Post-1973 Productivity Slowdown

Having examined the change in productivity during the 1970-73 period, we move on to the "change in the change" - the difference in productivity growth between 1970-73 and the following three-year period, 1973-76.

The third column of Table 2 gives the 73-76 decomposition of cost changes that is equivalent to the numbers for 1970-73 analyzed above. Because our concern is with the differences between the periods, column 2 of the table shows the result of subtracting earlier- from later-period figures.

Check first that a slowdown did indeed occur. The bottom line of the table shows that manufacturing productivity growth became negative in 1973-76 - manufacturing unit costs increased, with the change from 1970-73 being more than three percentage points.

What accounts for this slowdown? Looking first at "between-" or inter-industry factors, we see (row 14) that the process of shifts in the share of output towards higher-cost industries slightly intensified in the second period, but only accounted for about one-thirtieth of the increase in costs.

The difference between rows 12 and 13 means that the unweighted average of cost changes of the 144 industries was higher

than the eventual impact on the sector as a whole, implying that the largest cost increases were in smaller industries - those which had, on average, the biggest cost decreases in the previous period, as noted above.

It was suggested above that the decreases could be explained if smaller industries tend to be newer industries, subject to "learning-curve" and other scale economy cost reductions. If so, then whatever factor(s) permitted these cost reductions to be realized - output growth being the obvious candidate - must have reversed itself in the 1973-76 period. This hypothesis will be tested in the econometric work.

Moving to the intra-industry figures, we note first the decline in the output share of exits in the second period (row 1). This phenomenon resembles the decline in turnover that is observed in recessions in labour markets, when although involuntary turnover (lay-offs) increases, voluntary quits decrease by a larger amount, resulting in a net reduction in turnover.[8] However, the cost disadvantage of the plants that do exit is larger in the second period than in the first, to the extent that exits increase their contribution to reducing industry costs (row 2).

It may be of interest to look at the numbers of plants involved. On average, 5.5 plants exited from each industry between 1970 and 1973, and only 2.0 between 1973 and 1976. The fall in numbers is greater than the fall in output share (row 1), implying that plants exiting in the slowdown period were larger than those exiting in the normal-growth years from 1970-73. This is probably not

surprising -- in periods of growth, exits are mainly from the perennial 'fringe' of small enterprises that move between one industry and another. In recessionary times, however, alternative opportunities for these small operators dry up, and they are forced to 'batten down the hatches', and hang on to whatever activity they find themselves in (analogous to workers in firms). It is involuntary turnover that is increased by a recession, and this can be expected to affect a wider range of plants -- hence the increase in average size.

In summary, the process of plant closings goes against the trend of cost increases that mark the productivity slowdown. However, as comparing row 2 and 15 of the second column of Table 1 reveals, there is a factor of one hundred between the quantitative importance of the opposing effects.

Entry falls sharply (row 10), and so too does the cost-increasing contribution made by new plants (row 11). But it is miniscule in any case.

Thus, the major factor in the slowdown must be changes in the productivity performance of surviving plants. Row 9 of column 2 confirms that this is so, and comparison of rows 7 and 8 with row 3 reveals that the slowdown amongst surviving plants was approximately evenly distributed across the cost distribution. There was not, for example, a larger increase in costs amongst plants with relatively low costs in 1973.

That is, the productivity slowdown after 1973 is accounted for by a fall in productivity growth in the sector of plants that accounted for most of the productivity growth in the 1970-73 period,

and appears to have been a phenomenon widely spread across this sector. It is this phenomenon that needs to be explained.

2.3.3 Productivity Growth After 1976

The data base was split into three periods. This enables us to ask the very important question: "Was the post-73 slowdown permanent?" We may note at once from row 15 of Table 2 that there was a recovery of 2.88 percentage points in productivity growth in 1976-79 compared with 1973-76 - very nearly sufficient to get manufacturing costs decreasing again as fast as in the 1970-73 period.

Disaggregation of the aggregate number unveils some very interesting patterns. Compare rows 12 and 13 of column 5. Row 12 implies that, on average, industry-level productivity performance in 1976-79 exceeded the pre-slowdown performance in 1970-73, but there is a difference of nearly one percentage point between the unweighted average of row 12, and the weighted average of row 13. This divergence in the productivity performance of relatively small and relatively large industries. Smaller industries showed improvements in costs, and/or larger industries failed to share in the productivity recovery of the others.[9]

At the intra-industry level, we can observe other interesting aspects of 1976-79 behaviour. Flows of exits and entrants increase compared with 1973-76, without regaining the rates of 1970-73. As before, their quantitative contribution to productivity growth is not large. Amongst surviving plants, there was a tendency for the cost distribution to flatten, due to relatively larger decreases in

costs amongst plants that were in the high-cost segments of their industries in 1976 (row 7).

Finally, at the industry level, row 14 reveals that output shares at last moved in the "right" direction - with relatively low-cost industries increasing their share of manufacturing output, as they had not done in either of the previous periods.

To summarize the main findings of this section:

(a) Before 1973 productivity growth in manufacturing was almost entirely attributable to cost improvements achieved by plants surviving through the period.

(b) There was a sharp slowdown in productivity growth in the 1973-76 period, due almost entirely to a deterioration in the cost performance of surviving plants.

(c) There was a recovery in productivity growth after 1976, due mostly to a pick-up in the cost performance of surviving plants, especially those with high costs (relative to other plants in their industry) in 1976, and assisted by a reallocation between industries of output shares in favour of lower cost industries.

It should be noted that the "surviving" plants of one period are not necessarily the survivors of the next. Some plants lasting through 1970-73 exited in later periods. And some of the survivors in the later periods would have entered after 1970. Thus, for example,

although new plants are apparently not able to contribute, on average, to industry cost performance when they are less than three years old, in later years they may be responsible for much of the productivity improvement that our sample attributes to "surviving" plants in general.

A final point: the reader may have noticed the difference between the near-complete recovery of unit real variable costs documented in this chapter, and the only partial recovery of real domestic product per employee, noted in Chapter 1, over the 1976-79 period. There is, of course, no reason for these different measures of productivity to behave identically, but there may also be data differences -- RDP as shown on Table 1 grew less over the 1976-79 period than did the figures corresponding to the data behind Table 2.

3. Explaining the Slowdown

What economic forces underly the changes in productivity growth charted in the previous sections? The post-1973 slowdown was strikingly coincident with two other events:

- the OPEC-induced 'explosion' in oil prices
- a world-wide recession

In an econometric analysis of the aggregate Canadian economy (less the energy-producing sector), John Helliwell found

> fairly strong evidence that one-quarter or two-fifths of the post-1973 drop in aggregate productivity (depending on whether 1982 or 1981 is used as the terminal year) is due to changes in factor proportions, induced by higher energy prices, with almost all the rest caused by decreases in capacity utilization due to low sales and profitability. In terms of underlying causes, almost all the changes in factor proportions, sales, and profitability were due to the OPEC price shocks and the related changes in inflation and real GNP elsewhere in the world.
>
> (1984, p. 211)

The results to be presented in this chapter for the Canadian manufacturing sector will be broadly supportive of Helliwell's findings. That is, it is indeed the two most obvious proximate events that were responsibble for the Canadian productivity slowdown.

In section 3.2 a quite simple econometric model incorporating energy price and capacity utilization effects will be estimated on the disaggregated database. The split of one data period into three will allow us to test this model not only on the slowdown years, but for its ability to explain the post-75 productivity growth recovery.

Before getting to the econometrics, however, it is necessary to consider a quite long list of factors which apparently do not help explain what happened after 1973, although they have been put forward, in Canada or in the U.S., as possible culprits to blame for the slowdown. This list is dealt with next, in section 3.1.

3.1 Factors which do not explain the Productivity Slowdown

In a production function framework, factors contributing to a change in the productivity of an input can be sorted into two classes:

(1) changes in the quantities of other inputs.

(2) changes in the relationship linking output to inputs.

For example, the fall in variable-factor productivity with which we are concerned could have been caused by a fall in the capital input per unit of variable factors, or by a deterioration in the rate of technical progress reducing the productivity of all inputs.

In this section we will review the following factors:

- capital
- labour quality
- technical change
- regulation
- inflation
- sectoral shifts

Denny and Fuss (1982), and Sharpe (1983) also review lists of candidates to explain the slowdown.

3.1.1 Capital

It has been suggested that a fall in the rate of growth of the capital stock may help explain the fall in labour productivity growth. Such a reduction in capital services could come at either end of the capital stock age distribution - that is, there could have been a reduction in investment in new capital, and/or an increase in the rate at which existing capital is scrapped.

Nordhaus (1982) reports some slowing in capital formation in the United States after 1973, and attributes to this 0.3 percentage points of the 2.5 percent slowdown there. Denison (1979) gets a figure of comparable size.

Yet even these rather small numbers have been challenged by Bosworth (1982), who does not believe that capital growth has slowed significantly. In support are the findings of Griliches and Mairesse (1983), who found that capital formation was not to blame for the slowdown in the United States or France.

For Canada, the Department of Finance (1980) claim a role for a slowing in the growth of the capital/labour ratio; but there are problems with the way they 'correct' capital for cyclical fluctuations (Denny and Fuss, p. 24), and their findings are countered, for the manufacturing sector at least, by Berndt and Watkins (1981), who uncovered a surprising strength in capital formation from 1973 to 1976, which they consider one of the most puzzling events of those years. Helliwell predicts that steady-growth capital intensity would not have differed from its actual path (1984, pp. 198-9).

Possibly because the stock of capital is so hard to measure, it has always proved difficult to identify econometrically its contribution to the production process. For example, Rao (1979) estimated production functions for 25 Canadian manufacturing industries, and found "significant" coefficients on his capital stock variable in only three cases.

Nevertheless, the information that we do have makes it very unlikely, in my judgement, that measured changes in capital inputs can account for the sharp year-to-year-changes in productivity performance that marked the 1970s. Lack of capital stock data for 1973 and 1976 unfortunately will prevent us from testing this conjecture econometrically.

An interesting capital-stock related hypothesis is that of Baily (1982), who suggests that a significant proportion of the existing stock has been made obsolescent by changes in pollution regulations and higher energy prices. That is, our measured stock data, which deal with depreciation and scrappings by rigid formulae, may over-estimate the size of the economically viable capital stock after 1973.

For such phenomena to account for the post-1973 slowdown we would need to observe a sharp increase in rate at which existing capacity was scrapped at this time. Bosworth (1982) claims that the U.S. scrappage data do not support Baily. For Canada, we have the naw data presented in Table 2 of this study, which revealed that "exits" - plant closings - actually <u>declined</u> in the 1973-76 period.

Thus, without ruling-out a long-run decline in productivity due to economic obsolescence of the capital stock, we must conclude that the hypothesis is not helpful in explaining the sudden post-73 slowdown.

3.1.2 Labour Quality

It has been suggested that some of the apparent fall in labour productivity growth may be due to mismeasurement of the labour input itself. Increases in the proportion of the labour force that is young and/or female have supposedly lowered the "quality" of the labour input.

Whether or not these long-term demographic shifts have had an effect on the trend of productivity growth, it is most unlikely that they could have been responsible for the sudden fall in growth after 1973 (or for the subsequent partial recovery of the 1976-79 period). Nordhaus (1982) attributes no more than one tenth of a percentage point of the U.S. slowdown to declines in labour quality.

Indeed, given that the slowdown was accompanied by a recession, we might expect that average labour quality would increase, since it is presumably the less experienced and productive workers who are laid off when demand falls.

For Canada, Kaliski (1984) reports that some demographic trends (a younger and more female work force) that may have reduced labour quality through the 1960s and early 1970s, had, if anything reversed by the end of the decade. In any case, these structural

trends cannot be expected to explain the cyclical fluctuations we are here concerned with.

3.1.3 Technical Change

A recurring finding of the "growth accounting" literature that grew up in the years of relatively steady productivity growth was that most of the increases in output could not be explained by increases in the quantity of measured inputs - labour, capital, perhaps energy.

This leaves a substantial "residual" contributor to economic growth, which has been given several names, of which the most accurate is probably "the measure of our ignorance". However, it became common to call the unexplained residual "technical progress" or "advances in knowledge", though without direct evidence that would justify such an interpretation.

The costs of this casual treatment of a quantitatively important phenomenon became painfully apparent when, after 1973, the residual apparently collapsed. Denison calculated that the residual fell from having made a 1.4 percent per annum contribution to increasing labour productivity in the U.S. between 1948 and 1973, to a negative contribution of -0.7 percent for the 1973-76 period (Denny and Fuss, 1982, p. 30).

Whether or not it was reasonable to attribute such a large role in productivity growth to technical progress before 1973, it could hardly be suggested that the march of invention and innovation would suddenly reverse direction in such striking fashion, to

apparently partially recover three years later. As Denny and Fuss note (1982, p. 79), the matter is "perplexing".

The problem posed by the unaccounted-for residual is serious: it is not just the failure of the orthodox methodology to explain the slowdown that matters, but also the doubts that this failure casts on all that was believed to hold before 1973. However, the cyclical nature of productivity slowdown and recovery in Canada puts the puzzle of the residual outside the scope of the present study, fortunately. It remains, of course, an important subject for research on the determinants of long-term trends in economic growth.

3.1.4 Regulation

Increases in regulatory interference in business, resulting in various compliance (or evasion) costs that use up inputs but do not contribute to measured output, are often popularly supposed to have impeded productivity growth.

Economists, however, have not found evidence of a large quantitative impact of increased regulation. Nordhaus allows it 0.2 percentage points in his list of factors contributing to the U.S. slowdown (1982). It is beyond the scope of the present study to investigate changes in the regulatory environment and their impact in Canada, but it does not seem unreasonable to expect these to be minor over the time scale of this study.

3.1.5 Inflation

A Bank of Canada study (Jarrett and Selody, 1982) has claimed

to have "explained" most of the post-1973 Canadian slowdown by the concurrent increase in inflation. Helliwell (1984, p. 201) points out the problem with inferring causality from correlations - it may have been the decline in productivity growth that generated higher inflation. As well, both inflation and productivity growth may have been influenced by a third factor - the "stagflation" set off by the oil price-induced supply shock.

It is plausible that a sudden increase in the rate of inflation will generate some misallocation of resources, through various adjustment and information costs. But Jarrett and Selody do not model explicitly these misallocations, and past experience with the quantification of deadweight allocative losses suggests that it is most unlikely that inflation could account directly for the several percent of GNP wiped out by the productivity slowdown.

Nevertheless, the microeconomic costs of high (or variable) inflation rates are no doubt worthy of further research.

3.1.6 Sectoral Shifts

Even if productivity growth at the industry level is constant, growth at the sector or at the country level will change if the shares in output taken by individual industries alter. Most economies can attribute some of their economic growth to movement of labour out of low-productivity agricultural employment into the manufacturing sector.

Sharpe (1983, pp. 14-19) reports that such a shift occurred in Canada through the 1960s up until 1973, whereafter numbers employed in agriculture rose slightly, and there was, in addition, an increase in employment growth in some low-productivity service sectors.

Depending on the level of aggregation, and the output measure used, Sharpe's calculations show these sectoral shifts to account for as much as one quarter of the post-1973 productivity slowdown.

Our concern in this study, however, is just with productivity in the manufacturing sector, and we have already noted the implication of row 14 or Table 1 - that shifts in the output shares of manufacturing industries of differing levels of productivity accounted for less than one thirtieth of the slowdown of the sector as a whole.

3.1.7 Summary

To summarize this section: factors contributing to growth in output can be categorized as either (a) changes in the quantity of inputs to the productive process - capital, energy, labour; or (b) changes in the effectiveness, or productivity of given quantities of these inputs. We have tried to interpret the slowdown in labour productivity in the Canadian manufacturing sector in terms of these categories. On the evidence of previous work, as well as the new data supplied in the present study, the factors listed are not able to explain a satisfactory proportion of the slowdown. Something more is needed.

3.2 Modelling the Slowdown

We turn now to trying to explain just what did cause productivity growth in Canadian manufacturing to behave as it did during the 1970s.

The task is considerably simplified by what we have learnt already.

First, the accounting exercise of chapter 2 tells us that we do not have to build models of the entry and exit processes within industries, nor of the movement of resources between them, important though these phenomena may be for other purposes (such as explaining the long-term rate of growth). We can focus on what goes on inside plants that survive through each period. This, of course, restores us to the standard theory of a profit-maximising (or cost-minimizing) firm subject to price and technology constraints.

The second simplification is in the list of factors that are relevant to the firm's decision-making. There may be some important factor that no-one has noticed, of course, but confining ourselves to the list that has been paid attention to in previous research allows us, on the evidence of the previous section, to rule out all but the obvious factors -- energy prices and the 1974-75 recession -- as likely sources of blame for the slowdown.

To set the scene, figures 1 and 2 show how energy prices and capacity utilisation have varied in the 1970s. We look at each factor in turn.

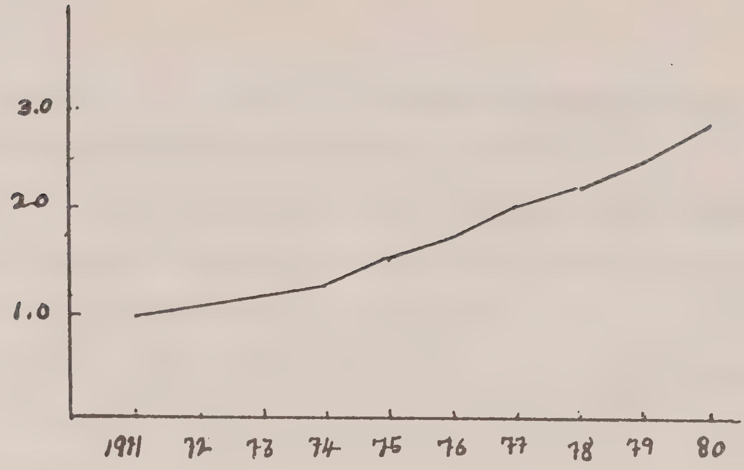

Figure 1   Price Index of Energy to Primary Users, 1971 = 1.0
(source: Helliwell *et al.*)

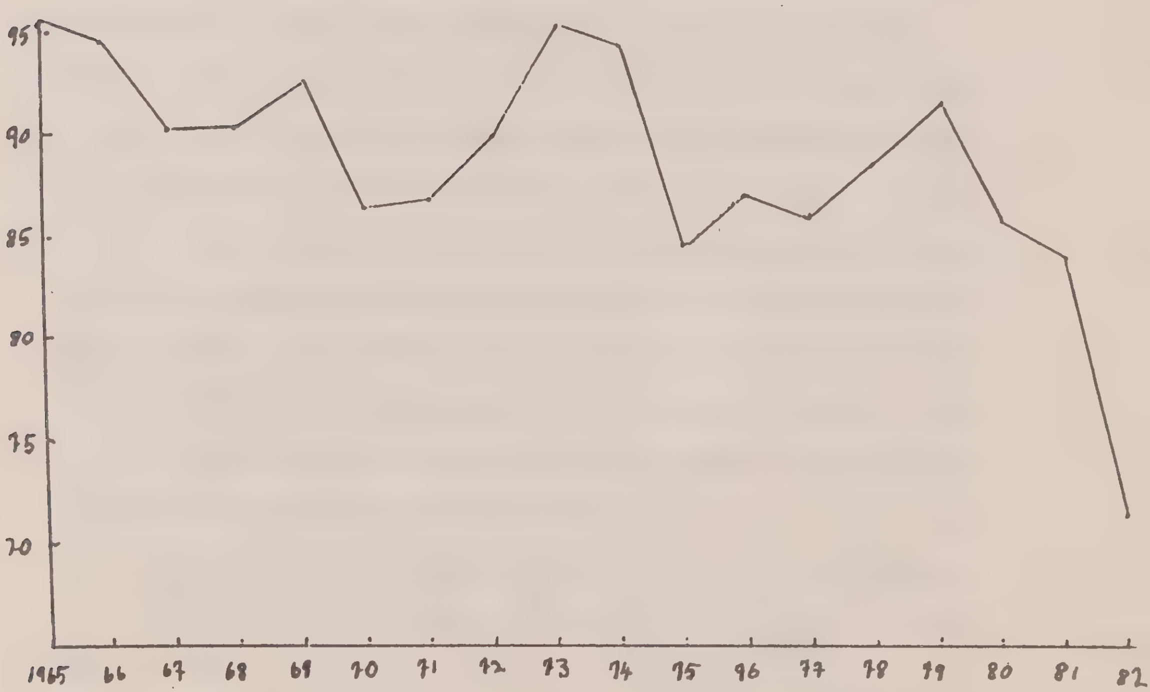

Figure 2   Percentage Capacity Utilization in Manufacturing
(annual average; source: Bank of Canada/CANSIM B 60003)

3.2.1 The Energy Price Increase

Unlike most OECD economies, Canada, as a net energy exporter, was able to smooth-out the domestic impact of the OPEC world oil price increases, as figure 1 shows. But the eventual increase was substantial -- to prices in 1980 around 2-1/2 times their 1971 levels -- and was presumably easily anticipated by Canadian firms, after 1973, at least.

Thus we can expect adjustments to the new regime of (presumably) permanently higher energy prices to have begun soon after the 1973 price shock.

What form would these adjustments have taken? We have noted that the data on plant exits do not support the Baily hypothesis that energy price increases reduced the capital/labour ratio by inducing increased scrapping of newly inefficient capacity. But, within plants, energy conservation measures involving the increased use of other inputs could have, and should have, been undertaken once the size of the energy price increases became known. For example, a plant can be replaced or upgraded to new energy-saving specifications, insulation can be added, and employees can be assigned to monitor energy use. Energy substituting activities can reduce variable-factor productivity in two ways: (1) a <u>temporary</u> loss in output with set-up costs and learning the problems of learning how to operate new techniques; (2) a <u>permanent</u> loss if running a more energy-efficient operation involves a permanent diversion of management and labour to monitoring and other tasks that do not produce measured output.

In 1970, before energy prices began to increase sharply, total expenditure on fuels and electricity were "only" about 2-1/2 of total variable costs, in manufacturing. Because of this, and because he believes that substitution possibilities in short to medium term are not very extensive, Sharpe concluded that

> 'the direct impact of higher energy prices on productivity growth (as opposed to the indirect effect on productivity via reduced aggregate demands) has been small' (1983, p.22),

and included energy prices in a list of eleven factors accounting, in total, for 'around 20 to 30% of the slowdown' (1983, p. 26). Denny and Fuss report U.S. work by Dale Jorgenson and associates using a multi-sectoral econometric model which comes up with quite sharp effects of energy price changes on productivity growth, but report that a quite similar Canadian model (Denny, Fuss and Waverman (1979) did not match the U.S. results (Denny and Fuss, p.33).

Against this, we must put Helliwell's recent results that (as noted above), assign between a one quarter to two fifths of the aggregate economy labour productivity slowdown up to 1981 or 1982 to changes in input proportions induced by higher energy prices.

Hopefully, the disaggregated database assembled for the present study will help us identify

> 'linkages between rising energy prices and falling productivity that are explicit enough to permit adequate quantitative measures of the impact'
>
> (Denny and Fuss, p.33)

3.2.2 Capacity Utilization and the Recession

The procyclical relationship between output and productivity is well known under the name "Okun's Law". When the economy moves out

of a recession, unemployment falls, but by a relatively smaller amount. One rule of thumb that was applied to Canada over the 1970's was that a two percentage point increase in the rate of output growth reduces the unemployment rate by about one point.[10] Because of the 'encouraged-worker' effect (the labour force increases when unemployment falls), the relationship between output and employment changes is not also two-to-one, but it is, in general, greater than one-to-one.

That is, when output rises in the business cycle, employment increases by a smaller percentage amount, so that labour productivity increases. Conversely, going into a recession, employers lay off a smaller-than-proportional amount of their workforce, so that measured productivity falls. The reason for this appears to be that labour is not a truly 'variable' input. Operating and maintaining capital stock, and administering firms, are activities for which the labour input requirement (called 'overhead' labour) does not vary much with output over the short-to-medium term (i.e. over the time span within which the size of firm is exogenous). And various adjustment costs connected with recruiting and training workers encourage firms to 'hoard' labour in recessions, in expectation of an eventual upswing.[11]

Sharpe's data on 119 Canadian manufacturing industries (1983, p.35) show that 104 of these had slower real output growth over 1974-78 compared with the 1961-73 period, and that 88 of the 104 also had lower labour productivity growth.

Since the ratio between materials inputs and gross output is virtually constant from one year to the next[12] -- that is, materials are a truly variable factor -- we should expect that the relationship between output and total 'variable' (materials plus labour) inputs would be pro-cyclical, but less so than the output-labour linkage. That is, we can expect that some of the variable-factor productivity slowdown after 1973 will be explained by the concurrent recession.

A problem with comparing productivity with output growth is that the latter does not distinguish between cycles and trends. A change in productivity can be due to a movement along a given short-run cost curve, or to a shift in the short-run curve -- a movement along the long-run curve.

Define the short-run average cost curve (SRAC) for a period t as the relationship between costs per unit output and scale of output, given the capital stock and other fixed inputs available at t, and the long-run average cost curve (LRAC) at t as the relationship between costs and output given the input prices and technology of period t, but assuming that cost-minimizing changes to capital stock and other inputs are made. The situation for two periods 1 and 2 is drawn on figure 3, on which $LRAC_2$ is above $LRAC_1$, perhaps because of an increase in the price of the energy input. Call the points of tangency between short- run and long-run curves K_1 and K_2, and suppose, for simplicity, that actual output, X, in period 1 is equal to K_1, and that period 2 output is less than K_2. Then the change in costs, C:

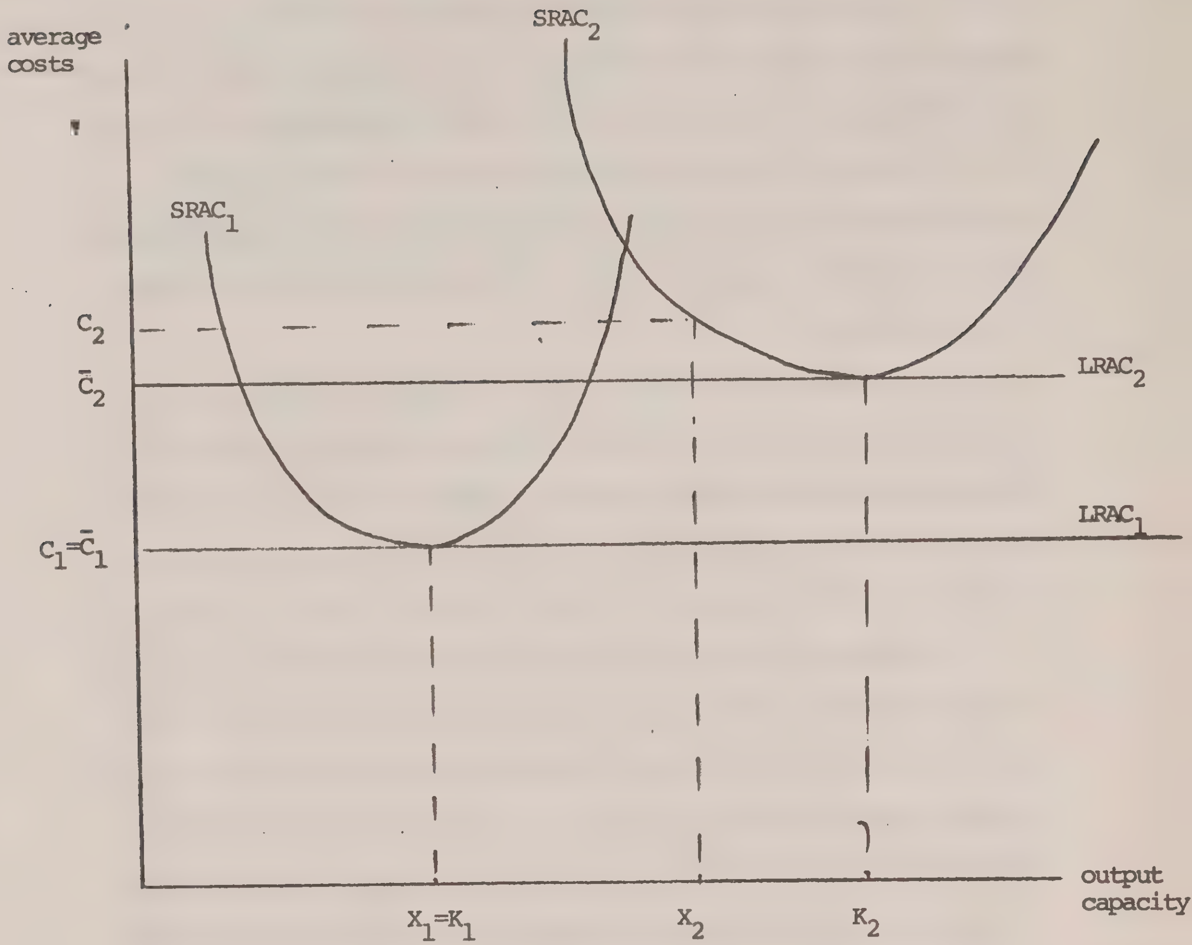

Figure 3 Average Cost Curves

$$C_2 - C_1 = (C_2 - \bar{C}_2) + (\bar{C}_2 - \bar{C}_1) \tag{28}$$

where $\bar{C}_t$ is average costs at K_t, and given that $\bar{C}_1 = C_1$.

Equation (28) decomposes the measured difference in costs (or productivity) between two periods into a short-term or cyclical component $(C_2 - \bar{C}_2)$ and a long-term component $\bar{C}_2 - \bar{C}_1$.

To explain changes in costs, then, we need to know about changes in capacity, K, and in factors shifting the long-run curve, and we need to measure changes in output relative to capacity output -- 'capacity utilisation' -- to pick up cyclical movements along short-run average cost curves. If we try and proxy the latter by changes in actual output, we may be misled. In the case of figure 3, for example, output has increased, but capacity utilisation has fallen, and it is this that is responsible for most of the increase in unit costs.

The empirical problem, of course, is that we do not in general observe capacity, K -- it must somehow be inferred. Helliwell (1984) handles this in an interesting way for his aggregate model. He defines 'synthetic' output in year t as a constant return to scale Cobb-Douglas function of employment in t and a 'vintage bundle' of capital and energy determined by current and past investment and relative energy/capital prices.

Synthetic output is thus the output that would be produced by the inputs used in year t, had these been subject to the property of constant returns to scale that is imposed on the (long-run) production function. The output actually produced in year t differs from this

synthetic output, presumably because of the quasi-fixed factor property of the labour input, noted above.[13] Helliwell calls the ratio of actual to synthetic output 'capacity utilisation', and notes that it accounts for most of the shortfall of output per employee below a hypothetical 'steady growth case' in 1981 and 1982 (1984, p.197).

It could be objected that there is an element of arbitariness in the definition of synthetic output, but its validity is supported by the equation which explains capacity utilisation econometrically in terms of profitability, aggregate demand and inventory disequilibrium, and which shows a very satisfactory goodness of fit (1984, p.215).

Although it will not be possible to replicate Helliwell's sophisticated procedures for our highly disaggregated sample, his results, though for aggregate data and for a longer time period than ours, underline the importance of making allowance for capacity utilisation effect on cyclical productivity fluctuations.

3.2.3 An Econometric Model

In this section we develop and estimate an econometric model of cross-sectional differences in productivity growth in Canadian manufacturing industries. We will take advantage of the results of duality theory and work with the cost function rather than the production function. The cost function captures the economically relevant aspects of the technology (Varian, 1984, p. 64), and, its advantages for our purposes are first, that costs are expressed in terms of variables, notably input prices, which may be taken as exogenous (whereas the production function is in terms of levels of inputs, which are themselves endogenous variables), and second, that we will not have to make the highly implausible assumption that all industries share the same technology or production function.

Following the standard procedure (eg. Berndt and Watkins, pp. 6-8), we begin with a fairly general 'KLEM' production function

$$Q_i = f_i(K_i, L_i, E_i, M_i, B_i) \tag{29}$$

which gives real output of industry i, Q_i, as a function f_i of the levels of capital, labour, energy and materials, and a technology 'shift' factor, B_i.

Total costs, C_i, are calculated as

$$C_i = p_{Ki}K_i + p_{Li}L_i + p_{Ei}E_i + p_{Mi}M_i \tag{30}$$

- the sum of products of input levels and input prices. Then the basic duality result is that minimising costs subject to the production function constraint gives

$$C_i = g_i(Q_i, p_{Ki}, p_{Li}, p_{Ei}, p_{Mi}, B_i) \tag{31}$$

cost-minimizing costs are a function of output, and input prices. If these variables can be taken to be exogenous, and if a plasible functional form is available, then the cost function (31) can be estimated econometrically.

Denote by the operator 'd' the derivative of a variable with respect to time, and drop, for temporary convenience, the industry subscript i. Then from (31) we move to

$$(32) \qquad dC = g_Q dQ + g_{p_K} dp_K + \ldots + g_{p_M} dp_M + g_B dB$$

For any variable y, call the proportional rate of change

$$(33) \qquad \dot{y} \equiv dy/y$$

so

$$(34) \qquad \dot{C} = \frac{Q}{C} g_Q \dot{Q} + \frac{pK}{C} g_{PK} \dot{p}_K + \ldots + \frac{B}{C} g_B B$$

Shepherd's Lemma (Varian, p. 54; Berndt and Watkins, p. 7) states that, under the assumption of cost-minimization, the level of an input is equal to the partial derivative of the cost function with respecxt to the price of the input. Thus, for capital, for example,

$$(35) \qquad K = g_{p_K}$$

Making use of this lemma, and defining

$$(36) \qquad \alpha_K \equiv \frac{p_K K}{C}$$

- the share of capital in total costs, we can rewrite (34) as

$$(37) \qquad \dot{C} = \frac{Q}{C} g_Q \dot{Q} + \alpha_K \dot{p}_K + \ldots + \alpha_M \dot{p}_M + \frac{B}{C} g_B \dot{B}$$

Re-introduce the industry subscript i:

$$(38) \qquad \dot{C}_i = \frac{Q_i}{C_i} g_{iQi} \dot{Q}_i + \alpha_{Ki}\dot{p}_{Ki} + \ldots + \alpha_{Mi}\dot{p}_{Mi} + \frac{B_i}{C_i} g_{iBi}\dot{p}_i$$

Without any loss in generality, we can choose units for each industry's 'technology' variable, B_i, so that it equals costs, C_i. We will have to assume that there is no systematic tendency for industries to show either increasing or decreasing returns to scale, over the long-run, so that the elasticity of costs with respect to output

$$(39) \qquad \frac{Q_i}{C_i} g_{iQi} = 1$$

Summarize the effects of changes in 'technology' as

$$(40) \qquad \dot{b}_i \equiv g_{iBi} \dot{B}_i$$

Then (38) simplifies to

$$(41) \qquad \dot{C}_i = \dot{Q}_i + \alpha_{Ki}\dot{p}_{Ki} + \ldots + \alpha_{Mi}\dot{p}_{Mi} + \dot{b}_i$$

or

$$(42) \qquad \dot{c}_i \equiv \dot{C}_i - \dot{Q}_i = \alpha_{Ki}\dot{p}_{Ki} + \ldots + \alpha_{Mi}\dot{p}_{Mi} + \dot{b}_i$$

- the rate of change of costs per unit output is the share-weighted sum of input price changes, plus the effect of all other factors shifting the underlying production technology. It is these shifting effects, of course, on which this study is focussed, so we must specify the determinants of $\dot{b}$. The evidence of extant work at the aggregate level; as summarized in the previous sections, points to sudden and large changes in energy prices -- which may have forced

firms off their production functions as they devoted resources towards making long-term adjustments to technology and factor proportions to cope with a new regime of permanently more expensive energy -- and to a fall in capacity utilisation -- forcing firms up their short-run cost curves -- as the most plausible culprits for the post-1973 productivity growth slowdown. However, any unusual change in input prices could temporarily force firms off their cost curves. In general, we can write

$$(43) \qquad \dot{b}_i = h_i(\dot{U}_i, \dot{p}^v_{Ki}, \dot{p}^v_{Li}, \ldots)$$

where $\dot{U}$ is the rate of change of capacity utilisation, and the $\dot{p}^v$ are unexpected rates of change of prices. In the absence of expectation data, we will have to assume that actual price changes can proxy unexpected. It is probably reasonable to assume, also, that the impact of an input's price is proportional to that input's share in total costs. In the absence of theoretical guidance, we will assume that the function h is approximately linear. With all these assumptions we can write

$$(44) \qquad \dot{b}_i = a_i + b_i\dot{U}_i + c_i\alpha_{Ki}\dot{p}_{Ki} + \ldots + f_i\alpha_{Mi}\dot{p}_{Mi}$$

Substituting (44) into (42) gives

$$(45) \quad \dot{c}_i = a_i + b_i\dot{U}_i + (1+c_i)\alpha_{Ki}\dot{p}_{Ki} + \ldots + (1+f_i)\alpha_{Mi}\dot{p}_{Mi}$$

This is an expression for cost changes that includes a number of industry-specific coefficients which we will not be able to estimate from our cross-sectional database. We are forced, then, to assume that the coefficients b_i through f_i are the same across industries. If this is not a reasonable assumption the goodness of fit of the regression model will not be high.

However, it would be extremely implausible to force the a_i to be equal. This parameter picks up all the long-term sources of differences in productivity growth rates that are assigned to the 'residual' in time series studies of productivity growth, and which do, we know, differ substantially across industries (Zohar).

We do, however, have 3 observations on each of our sample of industries, for the three periods 1970-73, 1973-76, and 1976-79. If we are prepared to assume that each industry's 'residual' did not change much over the 1970-79 period, and that the other coefficients and input share weights are also stable, we can combine our three observations into pairs, and so eliminate the constant term a_i. Using the notation

(46) $$\Delta y = y_t - y_{t-1}$$

- the change in a variable y from one period t-1 to the next period, t, we have

(47) $$\Delta \dot{c}_i = b_i \Delta \dot{U}_i + (1+c)\alpha_{Ki}\Delta \dot{p}_{Ki} + \ldots + (1+f)\alpha_{Mi}\Delta \dot{p}_{Mi}$$

The model (47) is now almost in a form that we can estimate with the available data. The only remaining problem is that we do not have data (in the Census of Manufactures) on capital costs and prices. Thus the capital price change term must be dropped from (47), and the unit cost change variable includes only 'variable' costs - labour, energy, and materials. We have noted the evidence of Berndt and Watkins that changes in capital stock are not apparently a factor in explaining the post-1973 productivity slowdown at the aggregate manufacturing level. Hopefully, the omission of capital price effects

from our model is not problematic.

The final specification of the cost function model is, then

(48)

$$\Delta\dot{c}_i = b\Delta\dot{U}_i + (1+d)\alpha_{Li}\Delta\dot{p}_{Li} + (1+e)\alpha_{Ei}\Delta\dot{p}_{Ei} + (1+f)\alpha_{Mi}\Delta\dot{p}_{Mi}$$

which will be estimated for two pairs of time periods - the slowdown 1973-76 period compared with high-growth 1970-73, and the recovery period, 1976-79, compared with 1973-76.

Data

The variables in (48) were measured thus:

c_i is the ratio of total labour, energy and material costs, in current prices, to real gross output, for industry i.

U_i capacity utilisation is measured as real gross output of industry i as a proportion of 'full capacity' output. Full capacity was calculated simply by assuming that output was at capacity in the end-years 1970 and 1979, and grew linearly between those years. This assumption is, on average, likely to be false, as figure 2 showed that, for the whole manufacturing sector, capacity utilisation was higher in 1979 than in 1970. An alternative measure is the Bank of Canada capacity utilisation index, which has recently become available for most of the 3-4 digit SIC industries under study here. Both measures were tried out.

p_{Li} calculated as wage plus salary payments per employee. This measure of the price of labour does not correct for changes in the composition of an industry's labour force, for nonwage benefits, or for changes in overtime hours worked. Unfortunately, proper indexes of wage rates are not available in Canada, even at the 2-digit SIC level.

p_{Ei} Statistics Canada have recently computed and made available unpublished indexes of changes in price indexes of energy and fuels for each 3-4 digit SIC industry.

p_{Mi} Statistics Canada have also prepared disaggregated indexes of total materials and fuels input prices. After subtracting the energy price index (weighted by energy's share for each industry, in total input costs), this index is used as our materials price index.

α_i the shares of labour, materials, and energy in total costs in each industry in 1970 were calculated from the Census of Manufactures.

<u>Regression Results</u>

The results of ordinary least squares regression of the model of equation (48) on data for 121 Canadian manufacturing industries are shown on Table 3. In the first three regressions the dependent variable is the rate of change of unit costs over 1973-76 minus the rate

of change in 1970-73. In regressions four through six the dependent variable is the difference between the 1976-79 and 1973-76 rates of change of unit costs. Thus the first set of regressions is aimed at explaining cost changes over the slowdown period, and the second deals with the late-1970's recovery.

Means and standard deviations of the variables as they appear in the regressions, and of these variables for each of the three-year periods are shown on Table 4.

The three regressions for each pair of periods differ according to the specification of capacity utilisation, as explained in the Notes to the table.

Observe *first* that the Bank of Canada utilisation index used in regressions 3 and 6, does not do as well as the rather crude index calculated without direct data on normal capacity, and, *second*, that the linear-plus-quadratic specification of the latter index (regressions 1 and 4) does better in the first period, and almost as well in
1 the second period, as the difference-in-ratios specification (regressions 2 and 5). After checking that the coefficients of the other variables do not fluctuate a lot when the utilisation specification is changed, we will focus attention on regressions 1 and 4.

The constant term will pick up the effects of any omitted variables, and misspecification of the functional form. Compared to the mean values of the dependent variables (see Table 4), the estimated constants are probably small enough to imply that misspecification is not a significant problem.

Table 3 Explaining differences in cost changes

Dependent variable ΔC	Constant	$\alpha_L \Delta \dot{P}_L$	$\alpha_E \Delta \dot{P}_E$	$\alpha_M \Delta \dot{P}_M$	$\Delta \dot{U}^a$	$\Delta \dot{U}^b$	ΔdU^a	ΔdU^{a2}	$\bar{R}^2$
1. slowdown: 1970-73 rate of change subtracted from 1973-76 rate of change	-0.026 (-1.0)	1.253 (3.8)	1.689 (6.0)	1.006 (17.9)			-1.52 (-4.9)	0.733 (4.6)	0.798
2.	-0.000 (-0.0)	1.169 (3.3)	1.778 (5.8)	1.047 (17.5)	-0.138 (-2.4)				0.766
3.	-0.000 (-0.0)	1.252 (3.4)	1.707 (5.5)	1.064 (17.1)		-0.030 (-0.8)			0.756
4. recovery: 1973-76 rate of change subtracted from 1976-79 rate of change	-0.030 (-1.3)	0.470 (1.5)	1.158 (3.2)	1.148 (18.9)			-0.518 (-2.5)	0.199 (1.5)	0.791
5.	-0.031 (-1.4)	0.447 (1.4)	1.175 (3.2)	1.157 (19.2)	-0.172 (-3.4)				0.792
6.	-0.051 (-2.5)	0.272 (0.8)	1.131 (3.0)	1.173 (19.2)		-0.105 (-2.5)			0.782

Notes for Table 3

1. Sample of 121 Canadian manufacturing industries.

2. Ordinary Least Squares Regression (t-statistics in parentheses).

3. Measures of capacity utilisation:

   U^a is the measure described in the text, which assumes that 1970 and 1979 were 'normal capacity' years, and linearly interpolates to get 'normal capacity' for 1973 and 1976.

   U^b is an index of capacity utilisation prepared by the Bank of Canada and supplied by Gerald Stuber. An article explaining the methodology is in the Bank of Canada Review, May 1980.

   dU^a is the arithmetic difference beteen measures of U^a at the stard- and end-year of each three-year period. dU^{a2} is the difference of the squared values of start-year and end-year U^a.

Table 4 Means and standard deviations of variables

	Variables	Period	Mean	Standard Deviation
1.	$\Delta\dot{C}$	ba	0.284	0.243
2.	"	cb	-0.133	0.237
3.	$\alpha_L\Delta\dot{P}_L$	ba	0.061	0.030
4.	"	cb	-0.046	0.032
5.	$\alpha_E\Delta\dot{P}_E$	ba	0.015	0.036
6.	"	cb	-0.008	0.027
7.	$\alpha_M\Delta\dot{P}_M$	ba	0.164	0.185
8.	"	cb	-0.035	0.170
9.	$\Delta\dot{U}^a$	ba	-0.098	0.191
10.	"	cb	0.180	0.205
11.	$\Delta\dot{U}^b$	ba	-0.227	0.296
12.	"	cb	0.180	0.244
13.	ΔdU^q	ba	-0.073	0.221
14.	"	cb	0.168	0.151
15.	ΔdU^{q2}	ba	-0.093	0.430
16.	"	cb	0.280	0.238
17.	$\dot{c}$	a	0.150	0.134
18.	"	b	0.434	0.172
19.	"	c	0.301	0.158
20.	$\alpha_L\dot{P}_L$	a	0.084	0.029
21.	"	b	0.145	0.050
22.	"	c	0.099	0.038
23.	$\alpha_E\dot{P}_E$	a	0.027	0.042
24.	"	b	0.043	0.076
25.	"	c	0.034	0.053
26.	$\alpha_M\dot{P}_M$	a	0.098	0.120
27.	"	b	0.262	0.122
28.	"	c	0.226	0.125
29.	$\dot{U}a$	a	0.861	0.138
30.	"	b	0.762	0.096

continued

Table 4 (Continued)

	Variables	Period	Mean	Standard Deviation
31.	"	c	0.942	0.156
32.	$\dot{U}^b$	a	1.136	0.214
33.	"	b	0.908	0.155
34.	"	c	1.088	0.180
	α_L	1970	0.329	0.107
	α_E	"	0.025	0.038
	α_M	"	0.646	--

Note - Key to periods:

a = 1970-73
b = 1973-76
c = 1976-79
ba = (1973-76) minus (1970-73)
cb = (1976-79) minus (1973-76)

In the slowdown period, all three share-weighted input prices had a strong effect on cost changes. Materials account for about 2/3 of total variable factor input costs (Table 4), and the materials price change coefficient is highly significant, and close enough to one to suggest that the slowdown in productivity growth after 1973 was not due to non-energy input price shocks. The labour price coefficient is rather larger than one, but its t-statistic is not high enough for us to be confident that the difference matters.

The most interesting coefficient, of course, is that of energy price changes. It is well above one, and significant enough to suggest that the excess matters. That is, the increase in unit costs associated with changes in the rate of growth of energy input prices was more than can be accounted for by the direct impact on cash costs (i.e. by a coefficient of one), consistent with the hypothesis that the energy price shock forced firms off their production functions as they scrambled to make adjustments in technology to accommodate the new permanently higher energy price level.

The net effect of changes in capacity utilisation was also to increase costs. Table 5 sets out the contribution each variable made, on average, to the history of cost changes. The table distinguishes between movements along cost curves, and <u>shifts</u> in the curve -- the latter being, of course, the focus of our interest. Not surprisingly (in inflationary times) most of the 28-point increase in the rate of unit cost change was due to movements along the curve (column 5). Of the remainder, we find, in the slowdown period, 1 1/2 percentage points due to labour prices (which, however, may not be a reliable

figure due to the relatively low significance of the estimated coefficient, noted above); one percentage point ascribed to energy price changes; very little to materials prices, and more than four points to the fall in capacity utilisation that took place after 1973.

In the recovery period, the picture becomes a little confusing. The coefficient of labour price drops a long way below one but loses significance, the energy price coefficient falls towards one, and the materials price index, still highly significant, increases above one. Table 5 reveals that a good 3 percentage points of the recovery in productivity growth can be attributed to the general improvement in utilisation rates. Although energy prices continued to rise in the late 1970s, the rate of increase moderated, and, in any case, appears to have been well-enough anticipated to not have generated any further shocks like those which apparently pushed firms off their production functions in the immediate post-73 years.

To summarize, if we ignore the unsatisfactory labour price coefficient, we can conclude that most of the measured shift up in the cost curve after 1973 can be attributed to the sudden jump in energy price inflation and the fall in capacity utilisation, with the latter being about 4 times more important than the former. By the time of the recovery period the shock effect of energy price increases had dissipated, and such downward shifting of the cost curve (relative to trend) that occurred can be attributed to a pick-up in utilisation rates.

Overall these regression results are, at least, interesting. Given that the dependent variable is a cross sectional ratio of

Table 5 Decomposing cost changes

	1	2	3	4	5	6	7	8	9	10
	mean change in growth of unit costs	Movements along cost curve:				due to shifts in the cost curve:				
		labour	energy	materials	TOTAL	labour	energy	materials	capacity utilisa-tion	TOTAL
slowdown: [73/76-70/73]	+0.284	+0.061	+0.015	+0.164	+0.240	+0.015	+0.010	+0.001	+0.043	+0.069
recovery: [76/79-73/76]	-0.133	-0.046	-0.008	-0.035	-0.089	+0.024	-0.001	-0.005	-0.031	-0.012

Calculated at mean values of variables for the 121-industry sample. Columns 2,3 and 4 equal the mean values x 10. Columns 6,7 and 8 equal the mean values times [the coefficient in regression 1 or 4 minus 1.0]. Column 9 is the sum of the mean values of the linear and quadratic capacity utilisation variables weighted by their coefficients in regressions 1 and 4. The discrepancy between column 1 and the sum of columns 5 and 10 is due to the constant terms in the regression.

change, the R^2s of around 0.8 are probably quite impressive (there are no similar studies for comparison) and there are plenty of high t-statistics. However, it is unfortunate that data limitations forced the imposition of similar coeffients across the 121 industry sample. Ideally, the cost function would be estimated on a pooled cross section/time series database of annual data, which would allow coefficients to differ across industries. As they stand, though, our results can reasonably be said to support the aggregate-data findings of Helliwell, that the Canadian productivity growth slowdown was due partially to energy price increases, and, rather more, to cyclical fluctuations in capacity utilisation.

4. Summary and Implications for Industrial Policy

In this concluding chapter we will first assemble, in point form, the main findings of this study, and then draw from them some implications for industrial policy.

4.1 Summary of Results

1. Over the short-run (periods of three years) it is the productivity performance of plants surviving throughout a period that is responsible for virtually all productivity growth. This is true of the high-growth 1970-73 period; of the years of the sharp productivity slowdown, 1973-76; and of the period 1976-79 when productivity growth picked up to some extent.
2. In the first two periods productivity performance was distributed quite evenly (on average) across the manufacturing sector, but from 1976 to 1979 it was the smaller industries that tended to reduce their unit costs the most. Thus manufacturing sector units costs fell by less in this period than the unweighted average of individual industry cost changes.
3. Although their contribution increased in the slowdown period, plant closings never contributed a substantial amount (never more than 2%) to manufacturing productivity growth.
4. New plants do not make a positive contribution to productivity growth when they are picked up within three years of their entry into the industry, and they tend to be smaller than existing plants. Thus it appears that new plants have typically to

operate initially at below-optimal scale, presumably due to the time it takes to 'shake-down' new facilities and/or to difficulties in building market share.

5. Even over three-year periods there is a good deal of intra-industry mobility in the cost distribution, such that plants which begin in the low-cost halves of their industry tend, <u>on average</u>, to increase their costs over the next three years. We do not know to what extent this is due to transitory cyclical factors and self-cancelling measurement errors, compared with permanent changes in firms' productivity performance.

6. Our regressions appear to support previous findings from time series studies (Helliwell, 1984) that capacity utilisation and the energy price shock are both important factors in explaining the productivity slowdown (and recovery).

7. A reduction in three-year real output growth of four percentage points increases unit costs by about 2 percent. This is true when we compare the second and first period, and when we compare the third and second, and so appears to capture the consequences of moving along short-term cost curves whose shape (though not, of course, position) is quite stable over the 1970-79 period.

8. The fact that plant exits actually <u>declined</u> in the slowdown period is direct evidence against the plant-scrapping hypothesis.

To summarize: Helliwell's (1984) resolution at the aggregate level of the mystery of the productivity slowdown in terms of cyclical capacity utilisation and adjustment to energy price changes is supported by our disaggregated manufacturing data. Perhaps in contrast to the United States, then, the Canadian productivity slowdown was not part of a long-term secular decline in the rate of technical progress. Cyclical fluctuations are reversible and the energy price shocks are 'once-for-all' events. Certainly, though, higher world oil prices do reflect the using-up of cheap energy sources, which will force a permanent decline, ceteris paribus, in the productivity of other inputs. As a net energy exporter, however, Canada's real national income is increased by energy price increases due to depletion in other parts of the world (see Hazledine, Guiton, and Froehlich, 1984).

4.2 <u>Implications for industrial policy</u>

What are the implications of our results for policies aimed at increasing productivity? We will not here attempt to formally integrate our findings into the large and often frustratingly messy body of analysis and prescription concerned with what has become known as 'industrial policy' or 'industrial strategy'.[14] But the results of this study do have some implications for what should, and perhaps more important, what should not be done by Canadian governments interested in improving the performance of their manufacturing sectors.

We found that the post-1973 slowdown in productivity growth

took place predominantly inside established plants, and was due to (a) the large increases in energy prices and (b) a widespread fall in capacity utilisation due to the recession of 1974-75.

On (a): this was caused of course, by events outside Canada's control. As an energy producer, Canada was able to slow the impact of higher world oil prices on the domestic economy, and it may be that the fairly smooth rate of increase that is revealed on figure 1 was in fact an appropriate response -- moving the price firmly towards the exogenous opportunity cost of energy, while doing so slowly enough to give industry time to make the appropriate long-run adjustments to their technologies without excessive short-run disruption to output and profitability.[15]

As for (b), the decline in capacity utilisation, our data have shown that a good deal of this was made up in the 1976-79 period. Indeed, the unweighted mean of unit cost changes over these three years was similar to the unweighted mean over 1970-73. However, the weighted mean -- the all-manufacturing figure -- was slightly smaller because the recovery was concentrated on smaller industries. Consistent with this is figure 2 which shows that manufacturing capacity utilisation at its peak was about four percentage points above the peak of 1979.

Thus there certainly is a place for a successful macro-economic policy that would raise effective demand in the Canadian economy and so enable the manufacturing sector to utilise its capacity more efficiently, especially given the appalling slide in utilisation

rates that began in 1980.

Now, this is hardly a novel recommendation. Something called 'capacity utilisation' is found to be closely linked with cyclical productivity fluctuations in the more aggregated time series macro-econometric model of the Economic Council (CANDIDE), and of John Helliwell and his associates. Nor does calling for a 'successful macroeconomic policy' substitute for specifying just what such a policy would look like. But our results at least (a) add to the already substantial evidence that macroeconomic policy is not just about the standard 'macro' variables -- inflation and unemployment -- but also concerns productivity growth; and (b) imply that if expansionary fiscal and monetary policy runs into inflationary difficulties before full employment is reached, this is not necessarily because real capacity constraints have been reached (ie. increasing constant-price marginal costs), since we found no evidence of the exhaustion of the pro-cyclical relationship between productivity and capacity utilisation over the 1970's. If, then, it is not shortages of capital and labour that abort efforts to expand the economy then the mechanisms that are to blame may be susceptible to direct policy intervention. For example, if inflation rates pick up in expansions due to self- fulfilling expectations on the part of price and wage setters, a direct controls program that short-circuited the expectations-formation process might enable real output and employment to be increased well beyond the levels that are currently regarded as feasible.[16]

Our results should not give much encouragement to the proponents of microeconomic 'industrial policy' aimed at improving productivity performance at the industry level or below.

First, the 'noisiness' of the regression results implies that, at the disaggregated level of 3 or 4 digit SIC industries, there are important factors affecting the performance of individual industries which are not accounted for by the standard 'economic' measured inputs -- capital, labour, materials and energy. Unless industrial policy enthusiasts can put up a cohesive and empirically based model that does explain historical differences in industry productivity performnce -- and such a model does not, to my knowledge, yet exist[17] -- they should exercise due caution in suggesting policies.

Second, our results do not appear to support a strategy of 'picking winners', aimed at identifying and encouraging <u>firms</u> likely to out-perform the market average. We found that new plants do not contribute very much to productivity growth, even over the long term. Growth is predominantly the result of things going on within existing plants. Nor do the historical data give us clues as to which existing plants are likely to do well. Recall from chapter 2 that about half of the cost differential between low-cost and high-cost halves of each manufacturing industry, on average was eliminated in just three years by intra-industry mobility -- by high-cost plants improving and low-cost plants falling back. That is, the 'winners' of one year are often the 'losers' of the next, and vice versa. And even if we were

able to isolate stable groups of 'good' and 'bad' performers, we would still be lacking the evidence for market failure that would justify spending money on the winners to help them do even better, or on the losers, to help them improve.

Of course these negative results do not prove that a successful industrial policy is impossible. But they add weight to the warnings from other quarters,[18] that specifying such a policy is not likely to be easy. It is probably reasonable to propose that the best we can do to enhance productivity performance at the micro level would be to get our macroeconomic house in order -- to maintain a high and stable level of effective demand. Not only would this have the benefit of smoothing-out the wasteful cyclical swings in productivity growth that were documented above, but it would provide the appropriate climate for firms to make the decisions on technology and investment that, presumably, determine our long-run rate of growth. But until we achieve a better understanding of the process of long-run growth, even this must remain a conjecture.

Footnotes

1. See Giersch and Walter (1983).

2. An interesting recent paper by Michael R. Darby (1984) claims that 'the productivity panic is based upon statistical myopia', at least when total factor productivity (capital as well as labour) is considered. Darby argues that there has been no substantial change in technical progress or total factor productivity growth in the U.S. over the entire 1900s. Faster-than-trend labour productivity growth between 1948 and 1965 was due to higher investment rates, as the economy compensated for low investment during the Great Depression and World War II (1984, p 307).

3. Clark has recently argued that there has not been a fundamental recovery in U.S. productivity growth in the last few years (1984).

4. Helliwell (1984) analyses the whole non-energy sector: Rao and Preston (1982) and Zohar (1982) work at the 2-digit SIC manufacturing level or above.

5. The capital stock data are generated by a survey, which covers about 80 percent of each year's capital expenditures in manufacturing. In the Baldwin-Gorecki database output-based scaling coefficients are used to "blow-up" the survey data to match the coverage of the variables from the Census of Manufactures.

6. The data were supplied by R.W. Collins of the Industry Product Division of Statistics Canada, Ottawa.

7. See Statistics Canada <u>Gross Domestic Product by Industry</u>, 1983, catalogue 61-213, Table 3, p. 88.

8. For evidence on labour market turnover, see Clark and Summers (1979).

9. In previous work with this database, I found that moving from unweighted to weighted averages induced an even larger contribution -- more than two percentage points -- to cost changes. This spurred me to look in the database for outliers. I looked at the eighteen industries big enough to contribute at least 1 percent of total manufacturing shipments (in 1974). There was one striking outlier -- SIC 323 (Motor Vehicles), which is one of the three largest manufacturing industries (with pulp and paper and petroleum refining) accounting for between 6 and 7 percent of total manufacturing shipments. According to the database, real unit costs increased by nearly 22 percent (!) in Motor Vehicles between 1976 and 1979. This surprising figure did not match the published figures (calculable from Statistics Canada 61-213 -- see footnote 7, above). I found that there had occurred what appears to be a combination of revision and transcribing error in the 1979 output and input price deflators recorded on the Baldwin-Gorecki

database from which they were drawn for this study. Compared with the, presumably correct, figures in 61-213, the input and output price deflators are approximately transposed. When productivity growth is recalculated with the revised data we find a one percent improvement over 1976-79, rather than the 22 percent decline. Because of the relatively large weight of Motor Vehicles in total manufacturing, correcting its unit cost change figure makes a noticeable difference to the sector's calculated performance.

It appears that the 1979 price deflators data entered onto the Baldwin-Gorecki database were preliminary. Fortunately, though, of the eighteen large industries, only the Motor Vehicles data differed significantly in the latest official Statistics Canada version. As noted, it seems that some sort of error was involved in this case.

The 1976 and earlier price deflators on the Baldwin-Gorecki database match the published figures.

10. Dornbusch, Fischer and Sparks (1982, p. 10).

11. For a survey of this literature, see Hazledine (1981).

12. Between 1971 and 1981 the ratio of constant price intermediate inputs to constant price gross output did not vary, from year to

year, by more than ± 1 percent from its mean value for the decade (calculated from Statistics Canada 61-213, Table 3).

13. Which is supported by Helliwell's employment equation which has a large coefficient (0.84) on lagged employment, implying quite slow adjustment of employment to its equilibrium level. (Helliwell, 1984, p. 214).

14. For an entree to this literature, see Zohar (1982, chapt. 4)

15. See Hazledine, Guiton and Froehlich (1984) for a general equilibrium analysis of Canadian energy pricing which includes a comparison of phased energy price increases with a 'cold turkey' policy of matching instantly changes in the world price.

16. I expand on these ideas in my book (1984).

17. I made an exploratory effort to use the database to analyse long-term productivity growth from 1970 to 1979. Because the database was not designed for this purpose -- in particular, its division into three-year periods means that the role of entry and exit, which might be expected to be more important over the long-run than it proved to be within the three-yearly horizon, cannot be properly examined -- the results are not reported in the body of the text, but a summary may be of interest. The main findings were -

- differences in capital stock growth did not have a discernible impact on inter-industry differences in productivty growth.

- after controlling for plant-size growth, industry output growth had a negative impact on productivity growth. Plant-size growth itself had a positive relationship with productivity growth. These findings are consistent with there being internal scale economies and external scale diseconomies (both of which appear to be exhausted at a higher-than-average output growth rates).

- none of various "competitive pressure" variables that were tried out (concentration changes, tariff protection, import share) had a strong impact on productivity.

- there was a quite strong association between productivity growth and the proportion of Research and Development workers in an industry's labour force.

The failure of capital inputs to show an effect on output may be due to the assumption, forced onto a cross-sectional model, that all industries are on the same production function. It would require a pooled cross section/time series database to correct for this.

18. For example, Dan Usher (1983) examines the costs and benefits of five existing industrial policy programs directed at firm-specific investment, and documents a number of the costs (deadweight losses, mistakes, rent-seeking) that must be set against the benefits of such policies.

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